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Tuesday June 3, 2003 Euroanaesthesia 2003 - Glasgow

INTRODUCTION

The emergence of digitized medicine initiated a trend towards new devices and computer technologies such as electronic records, electronic publications, personal digital assistants, web tablets, and wearable computers. Are they of use to the anesthesiologist? What are the applications in today's and tomorrow's anesthesiology practice? This workshop will address such issues and analyze current advantages and disadvantages of available technologies and open the door to get a glimpse into the future of computing in anesthesiology.

HANDHELD COMPUTING

Handheld computers including Personal Digital Assistants (PDAs) and web tablets are slowly penetrating our workplace. Several anesthesia programs in the US offer today a PDA for new residents. Many anesthesiologists have a Palm Pilot or Pocket PC device in their pocket while working in the operating room. According to Wall Street Online, 17% of the physicians in the US currently use PDAs [1]. Last year, 6% of doctors surveyed used a handheld computer to write prescriptions, up from 2% in 2000. Other sources suggest that the general use has increased from 15% in 1999 to 26% in 2001 [2]. Thirty-three % of physicians under the age of 35 were using PDAs regularly. It was estimated that about half of all physicians would use PDAs by the year 2006. Another report published by the American College of Physicians and American Society of Internal Medicine found that 47% of their members were using such devices in October 2001 [3]. Analyzing the survey results, they concluded that about 67% would use handhelds by the end of 2002. There is no doubt that handheld computers are on the way to become a commodity on the medical landscape.

A study by G. Kantor from the Department of Anesthesiology at Case Western Reserve University (University Hospitals of Cleveland) investigated the use of handheld computing in an anesthesia residency program [4]. All residents had to use a PDA to track their cases. Only 30% had used a PDA before but 100% found it very easy to use it after a short introduction period. Drug references and electronic medical texts were accessed daily/weekly whereas medical calculators were used a few times per month. When asked about benefits of PDAs the responders answered in the following order (very beneficial to less beneficial): ease of access to relevant knowledge, case tracking, personal organizer, portability, and ease of use. At the same time they observed the following problems: batteries running out, difficult data entry, data loss, accidental damage of the device, and insufficient memory. The investigators concluded that point-of-care access to knowledge is valuable, PDAs are easy to use, and when introduced department-wide users must be trained, supported, and encouraged. These results were consistent with the ones published by S. Lapinsky et. al from the University of Toronto in Canada [5]. They used handhelds in an ICU setting and concluded that PDAs have potential in ICU but are in need of customized programs for this special environment.

FIGURE 1 AND 2

Applications

PDAs are currently used for the following medical purposes:

- Access of educational information (ePublishing)
- Libraries (drug references)
- Databases (case tracking, performance evaluation)
- Medical records (patient tracking)
- Medical calculators
- Monitoring devices (EKG, pulse oximetry)
- Drug prescriptions
- Coding and billing
- Communication (combined handheld – cellular phone, PowerPoint presentations)
- Personal Organizer (day planner and contact lists)

Eighty percent of the responders in the American College of Physicians and American Society of Internal Medicine survey indicated that they used their PDAs to access drug information, 32% to reference for normal laboratory values, 21% to read medical educational content, and 21% to streamline coding and billing.

Access of educational information (ePublishing):

Despite the downside of reading large volumes of text on a small PDA screen more physicians start using this form of electronic content access. PDAs and their memory cards can store entire textbooks or multimedia collections and allow immediate searching of the content for topics of interest. Many established references have created handheld versions of their content: Griffith's 5-Minute Clinical Consult, Merck Manual, Harrison's Principles of Medicine, Red Book 2000, or Cline's Emergency Medicine [6]. The Internet Journal of Anesthesiology (www.ispub.com) has launched a first trial to format its content for handheld devices. Allscripts (www.allscripts.com) offers a variety of study guides such as "PediStat", "PocketAnatomy", or "PocketExercises" next to its drug libraries for pediatrics, adults, and geriatrics. GASNet (www.gasnet.org) expanded recently its web site with some PDA resources containing the Pediatric Syndromes, a Spanish Phrasebook and the Global Textbook of Anesthesiology. Electronic resources formatted for PDAs are becoming very popular and are expected to increase in both, number and quality.

Libraries (drug references):

Drug references seem to be the most favorite application of PDAs in medicine. Several vendors offer outstanding products. They can be used to check on specific drugs and make sure they don't interact unfavorably with any of the patient's usual medications. In addition, they will offer guidance with dosage and alternative medications. Some studies report that the use of drug reference libraries was able to reduce medical errors and achieve better patient outcomes [7].

Databases (case tracking, performance evaluation):

In the US, case tracking and reporting is required by the American Board of Anesthesiologists (ABA) and the Accreditation Council on Graduate Medical Education (ACGME). PDAs can be used to facilitate this activity. The goals of a case tracking PDA software package is to improve data collection efforts and data accuracy, to avoid data loss, to create annual reports for accreditation, and to record ongoing assessment of experience by case type, volume, teachers, patient identifiers, and technique. Optimally, case reporting should be combined with performance evaluation of residents. It is important to move from user-centric software towards program-centric modules allowing program directors to track and summarize the performance process of the residents. Currently available programs include "Anesthesia Assistant" or "Anesthesia Stat Tracker". The Electronic Media Information Technology (EMIT) committee of the American Society of Anesthesiologists (ASA) just recently created a taskforce to work on recommendations for good case tracking software for anesthesia programs and vendors alike.

Medical records (patient tracking):

PDAs are being used to store patient data. However, some argue that data entry is still cumbersome. Better integration with mobile keyboards and improved hand recognition software combined with pull down menus and check boxes allow today for better and easier data input. Two examples of patient tracking modules for PDAs are "PatientTracker" and "PatientKeeper." Both of the vendors claim that they currently serve over 45,000 physicians with their programs. The programs allow users to manage and store patient data directly on their PCs

while seamlessly synchronizing with their handheld devices. All of the patients' historical information may be securely stored and updated electronically at the point-of-care and synchronized between PC and PDA for viewing, anywhere, anytime. One of the modules includes as well an interface with any institution's legacy information system for retrieval of laboratory and other relevant data.

Medical calculators:

A variety of programs were created to help physicians with clinical calculations [8]. Programs such as MedCalc (www.medcalc.med-ia.net) offering 75 calculation programs and MedMath (http://smi-web.stanford.edu/people/pcheng/medmath/index.html) offering 35 formulas allow calculating body mass index, alveolar-arterial (A-a) oxygen gradients, anion gaps, cardiac output, Glasgow Coma Scale, unit conversions, and creatinine clearance to name just a few. Another program called MedRules is an application featuring useful clinical prediction rules taken from the medical literature (http://pbrain.hypermart.net/medrules.html).

Monitoring devices (EKG, pulse oximetry):

An increased number of commercial monitoring products are becoming available for handhelds. In the US, we have seen the introduction of pulse oximetry and EKG holter monitoring for PDAs. Japanese anesthesiologists introduced a pharmacokinetic-monitoring program for PDAs calculating real-time distribution of diprivan, midazolam, and opioids into the different compartments of the body. In general, PDA monitoring products can be divided into two categories: monitoring devices for the hospital setting and devices for patients to perform self-monitoring at home. An example of such a device is the "AirWatch". This handheld allows patients with airway disease to perform basic lung function tests at home and transfer the data via modem to a physician office. If the results are critical the patient is urged to come to the emergency room. Family practitioners were able to reduce unnecessary doctor visits using this device. An Australian company offers a web tablet that connects via wireless technology to the monitors in the operating room. Vital signs and anesthesia-related data are transmitted to an electronic record keeping system. Data about administered drugs are immediately transmitted to the pharmacy for billing and inventory purposes. Each anesthesiologist has its own tablet and the software automatically records entering or leaving the operating room. An included web camera allows for web teleconferencing with colleagues to get help if needed.

Drug prescriptions:

Several vendors offer medication management and prescription communication tools for PDAs. These handheld-based applications are built to increase efficiency by eliminating paper and improving turnaround time for requests to pharmacies, to provide point-of-care information about drugs and drug interaction, and to improve quality of care by decreasing medication errors caused by illegible handwriting.

Coding and billing:

The "dot.com" boom led to birth of a multitude of vendors offering coding and billing modules for PDAs. Many of these companies have recently declared bankruptcy. However, some survivors seem to do well and offer nicely integrated software to facilitate the daily work of healthcare professionals. It remains to be seen how well they deal with the new patient privacy regulation going into effect in 2003.

Communication (combined handheld – cellular phone, powerpoint presentations):

The combined cellular phone – PDA has emerged and is penetrating the market. Many companies try to offer the ultimate "All-in-one" PDA with e-mail, fax, and phone capabilities. Should the discussion about safety of use of cellular phones near patient monitoring devices ever be solved, such PDA-phones could easily replace pagers (one-way communication) and allow for two-way communication between anesthesiologists without any delays. PDAs can also be used for communication of educational content to an audience. Several vendors offer hardware to connect the handheld devices to a digital projector. Accompanying software enables the PDAs to run PowerPoint presentations and therefore replace the bulkier laptop computers.

Personal Organizer (day planner and contact list):

Applications such as contact lists, calendars, to-do-lists are amongst the basic functions of PDAs. Residents in the operating room can easily look up department-relevant names and pager numbers. Day-planners have been used by several anesthesia pain services to schedule and track daily patient visits. By synchronizing with a PC the program automatically codes, bills, and schedules for the next day.

Future

In the US, we start to see a trend from using a PDA as stand-alone device to using it as one-way communication device (patient data can be downloaded from the network to the PDA) to using it as two-way communication device (data are being transmitted to and from the PDA) [9]. In general, the PDAs will allow users to carry a magnitude of medical information and tools to the point-of-care. Interaction with networks will occur through wireless connections. Access to data stored in a variety of hospital computer systems and "hot-syncing" (synchronization of PDAs with PC or servers) will be immediate and accurate. Soon, batteries are expected to last much longer, processing power to be greater, and handwriting and voice recognition to be significantly better. Web tablets will interact with all monitoring devices and electronic record keeping systems in the operating room. Patients will be able to use handheld devices at home and directly interact via modem or cable connections with their physicians. Smart technology will integrate education, patient data transfer, digital imaging, wireless voice and data transfer, healthcare information, drug prescriptions, and automated billing into one single device and ensure accurate interaction of all applications with each other. At the end of the workshop, you will see a 5-minute movie demonstrating the handheld device of the future.

Summary

Handheld computers allow having information readily available at the point-of-care. One device replaces a small library of books and journals. Additional memory can be accessed in form of flash memory cards. Real-time access to searchable relevant medical content and results of laboratory values or other patient examinations will be clearly be of benefit to the physician. Better readability and quality of data will hopefully result in a decrease of medical errors. However, some disadvantages have to be taken into account. The screens are small, the battery life is too short, data entry can be slow and difficult, limited memory may hinder the use, and new regulations such as the US Health Insurance Portability and Accountability Act (HIPAA) will force physicians and hospitals to be very vigilant about protecting patient privacy [10]. Handheld devices are not very secure and patient data stored on these devices can easily be lost to unauthorized third parties. Partial solutions to the problem are password protected two-way communication devices that will only see but not download patient information from hospital servers, so-called "time-bomb" downloads of patient information (information on the handheld will be automatically deleted after a certain short period of time), and a variety of password and encryption technologies. Overall, when used appropriately, PDAs could improve efficiency in the daily life of healthcare professionals.

Wearable Computing

Anesthesiologists wearing a PC connected wirelessly to a keyboard on the arm and a retina display device on the head – Is this a scene seen only in science fiction movies? Certainly not! During this workshop, you will see how these futuristic devices look like and what they can do for the anesthesiologist.

Figure 3 and 4

Applications

Wearable computers are currently used for the following medical purposes:

- Data processing
- Patient monitoring
- Digital imaging
- Remote guidance

Data processing:

Wearable computers allow users to work with word processing and spreadsheet programs on the go. Better voice recognition will allow dictation into small wearable devices while performing medical procedures. The technology will integrate data real-time with other applications on the network such as billing or patient record keeping. A variety of text or imaging data can be transferred to the physician's retina without risking contaminating a sterile field.

Patient monitoring:

Vital data from the monitor can be transferred directly to the anesthesiologist's retina. The physician can now concentrate on the medical procedure rather than paying attention to a monitor located away from the patient. A study performed at the University of Washington in Seattle and presented at the 2002 Annual Meeting of The Society for Technology in Anesthesia [11] revealed results from using a device called "Nomad Personal Display" in the operating room. The investigators found that the anesthesiologists increased their time focusing on their patients by 48%, decreased the time to perform their tasks by 29%, decreased the amount of times switching their attention to the monitor by 89%, and decrease overall change in attention by 54%. Test subjects stated that the see-through head-up display felt natural and did not disturb them during procedures such as intubations.

Digital imaging:

Retina display projectors can be used to access digital images while performing medical procedures. The devices have already been used successfully during angiography allowing the physician to overlay fluoroscopic images with the operating field.

Remote guidance:

Wearable data transfer devices combined with retina display projectors are being used by paramedics in emergency medicine for remote guidance and point-of-care access of medical information. First experiences are encouraging. Users judged the devices to be very useful and not disturbing despite their bulkiness.

Future

As computer technology gets smaller and lighter many more applications of wearable computers or sensors will emerge. Retina display devices will allow anesthesiologists to concentrate again on the patient rather than on computer monitors placed on the anesthesia machine behind their back. Voice activated information retrieval will provide instant access to relevant visual information at the point-of-care.

Summary

Wearable computers are not a futuristic dream anymore. Their applicability is currently being tested in operating rooms or other point-of-care locations. Due to the early stage of the technology the devices are still bulky and not very light. Once they reach a mature stage they will easily integrated into equipment and professional clothes. The future will show how well wearable computers will be able to increase patient safety and improve real-time interactive data transfer.

REFERENCES

1. The Wall Street Journal Online. October 09, 2002. Online at http://www.wjs.com
2. Harris Interactive. Health Care News. August 15, 2001: 1-2. Online at http://www.harrisinteractive.com/news/allnewsbydate.asp?NewsID=345
3. ACP-ASIM Survey. American College of Physicians and American Society of Internal Medicine. October 25, 2001. http://www.acponline.org/college/pressroom/handheld_survey.htm
4. Kantor G. 2002 Annual Meeting of The International Society for Computers in Anesthesia. Cape Canaveral, Florida, USA.
5. Lapinsky S, Weshler J, Mehta S, Varkul M, Hallett D, Stewart T. Critical Care 2001. 5. 227-231. Online at http://ccforum.com/content/5/4/227
6. Balsbaugh T. The Internet Journal of Family Practice 2001. Volume 1 Number 2. Online at http://www.ispub.com/ostia/index.php?xmlFilePath=journals/ijfp/vol1n2/hand.xml
7. Rothschild JM, LeeTH, Bae T, Yamamoto R, Horsky J, Bates DW. American Medical Informatics Association AMIA Symposium 2000. Los Angeles, California, USA.
8. Embi P. Cleveland Clinical Journal of Medicine 2001. Volume 68 Number 10: 840-853. Online at http://www.ccjm.org/pdffiles/EMBI1001.pdf
9. Walpert B. ACP-ASIM Online. American College of Physicians and American Society of Internal Medicine. Online at http://www.acponline.org/journals/handhelds/nov02/hospitals.htm
10. Centers for Medicare & Medicaid Services. US Health Insurance Portability and Accountability Act (HIPAA). Online at http://cms.hhs.gov/hipaa/
11. Ross B, Naluai-Cecchini A, Ormerod D, Fine M, Hyde JP. 2002 Annual Meeting of The Society for Technology in Anesthesia. Santa-Clara, California, USA. Online at http://www.microvision.com/pdfs/medcase1.pdf